

S P E C I F I C A T I O N

A TECHNIQUE FOR CREATING A MACHINE TO ROUTE NON-PACKETIZED  
DIGITAL SIGNALS USING DISTRIBUTED RAM

5 Field of the Invention

The invention relates to non-packet signal routing or switching systems and more particularly to such systems that apply signals from a selected one of N sources to a selected one of M sinks.

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Background

In broadcast systems, video and audio data are transmitted between N originating sources to M destination sinks. Such systems cannot easily rely on packet networking technology because of the need for synchronization of the data. The sources may be recording from CD players, live feeds, digital video files, etc. The control of a broadcast facility may involve rapid switching between many such sources and sinks. Presently, there are three types of routers that are used for such systems: space multiplexing, time multiplexing, and a combination of the two. In space multiplexing, a different physical channel is formed between the source and sink as in a

classic telephone switching system. In time multiplexing,  
all sources and all sinks are connected to the same  
physical channel, each using a different time slot or  
slots. In combination systems, the endpoints obtain time-  
5 slotted data on multiple physical channels.

When a switching system grows in terms of the  
number of sources and sinks it must handle, problems attend  
all three different kinds of systems. In time multiplexed  
systems, the bandwidth of the common physical channel has  
10 to be increased in proportion with the number of routes  
sharing the channel. Also, each connected device must be  
connected to the physical channel which presents  
interference and signal attenuation problems as the  
physical channel's frequency rises. In space multiplexed  
15 systems, the complexity of the switch increases  
geometrically as the number of endpoints rises. This is  
because each source must be selectively connectable to each  
sink, so the number of possible paths grows exponentially  
with the number of sources and sinks.

20 There is a perennial need for switches that  
handle digital data synchronously, and that must remain  
time aligned, that do not grow in complexity too fast as  
the endpoint capacity of the switch increases.

# SUMMARY OF THE INVENTION

A switch using distributed random access memory (RAM) accepts time multiplexed inputs applied to a fast  
5 wide buss. The incoming data is imaged simultaneously by a plurality of RAMs. Upon complete imaging of a one bit of each of the inputs (collectively, a "block") by all the RAMs, another block is stored in successive range of memory cells. As each block is imaged, a respective output  
10 controller addresses the memory locations corresponding to the output stream for a respective signal to be time multiplexed on a respective output physical channel. Each RAM makes available to each output all of the incoming data. The output controller may select from a respective  
15 RAM only the data it requires to make up a respective output stream.

The technique is possible because of the high speed of large fast data busses and the electronics capable of addressing them. All incoming data on multiple physical  
20 channels, each of which may be time multiplexed, is applied to a single large buss. RAM that is capable of storing data on such high speed busses are written to with successive blocks of data from the buss. In a sense, the

many-to-many physical switch interconnects characteristic  
of the spatial multiplexed aspect of the switch are  
replaced by a single interconnect - the high speed buss -  
like the hub of a wheel. Thus, interconnect complexity  
5 does not scale at the high rate characteristic of spatially  
multiplexed switches. Rather, the physical switch  
complexity scales linearly with the number of endpoints.  
In addition, the frequency demands on the devices driving  
the receiving and output electronics can be limited as the  
10 number of endpoints grows.

The invention will be described in connection  
with certain preferred embodiments, with reference to the  
following illustrative figures so that it may be more fully  
understood. With reference to the figures, it is stressed  
15 that the particulars shown are by way of example and for  
purposes of illustrative discussion of the preferred  
embodiments of the present invention only, and are  
presented in the cause of providing what is believed to be  
the most useful and readily understood description of the  
20 principles and conceptual aspects of the invention. In  
this regard, no attempt is made to show structural details  
of the invention in more detail than is necessary for a  
fundamental understanding of the invention, the description

taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

5 BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a schematic representation of a non-packet router switch according to an embodiment of the invention.

10 Fig. 2 is an illustration of a possible flow and storing of bits over a time interval according to a particular exemplary embodiment of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Fig. 1, signals on separate physical  
15 channels 185 arrive at respective time multiplexers 180 of a switch 70 (generically, a signal transducer). The multiplexers 180 multiplex the several separate signals arriving on the respective physical channels 185 and output them on respective channels 190. The channels 190 may be  
20 applied to a buss 150 and read simultaneously into each of several random access memories (RAMs) 145. The RAMs 145 are simultaneously imaged with data from the buss 150 in blocks of arbitrary size, in an embodiment, each block

containing one bit from each physical channel 185. As a block is being written, another block is being read. The blocks may correspond to arbitrary areas of memory and reused so that the writing and reading operations over a given block alternate.

Each RAM 145 is read out by a respective addressing controller 121-124 controlled by a controller 110. As would be understood by a person of ordinary skill, the addressing controller 121-124 may be an addressing RAM (not shown) with a sequencer (not shown) where the controller 110 places a sequence of addresses in the addressing RAM which are sequentially applied to the address lines (not shown explicitly) of the respective RAM 145 in response to the sequencer.

By placing all the data from the buss 150 into RAM 145, portions of the signal on the buss 150 can be randomly accessed to generate a signal on a respective output channel 165 without the timing required if data were to be applied to the output channel 165 directly from the buss 150. The addressing controller 121-124 addresses the appropriate memory locations in each respective RAM 145 in an appropriate sequence on channel 165 to supply all bits required by the bit selector 140. The bit selector 140

finally generates a signal on a respective output channel 160 which may be time demultiplexed to form a final M output channels.

Referring now also to Fig. 2, data arriving at channels 1-N shown in Fig. 1 are illustrated as blocks, with one bit per block. A top row of bits 210 corresponds to the data sent on a first channel 1 (shown in Fig. 1). A second row of bits 212 corresponds to the data arriving on a second channel 2 (shown in Fig. 2). An Nth row of bits 214 corresponds to the data arriving on an Nth channel N (shown in Fig. 2). Note, the channels 1-N are indicated generically at 185 in Fig. 1. These rows 210, 212, through 214 represent any number of streams of data on separate physical channels 185. In the example embodiment, respective groups of these N streams 210, 212, 214 are time multiplexed by respective multiplexers 180 into N/5 time multiplexed streams 190. Although there are five channels combined per multiplexer 180 resulting in precisely N/5 multiplexed streams 190, this combination, as would be understood by a person of ordinary skill, is an arbitrary example and the number of channels 1-N per multiplexer 180 could vary from one to the next and need not even be a plurality for purposes of the invention.

Time multiplexed data streams 231, 232, and 233 represent  $N/5$  output signals from the multiplexers 180. As illustrated, the first bit of each channel 1-5 are interleaved temporally to produce the multiplexed data stream 231; the first bit of each channel 6-10 are interleaved temporally to produce the multiplexed data stream 232, and so on. The  $N/5$  multiplexed data streams 231, 232, and 233 are applied to the buss 150. In the example, the buss 150 is  $J$  bits wide and the bits are applied in order,  $J$  bits per buss cycle, to the five respective buss lines (represented by data streams 240, 242, 244) from the leading end of the multiplexed data streams 121, 122, and 123. The data then on buss 150 is read into a first portion 250, 254 of each of  $K$  RAMS 145 to create an identical image in each such first portion 250, 254. The first portion 250, 254 is filled up when  $N$  bits are written into them. Then, the address controllers 121-124 read from second portions 252, 256 of the RAMS 145 and respective bit selectors 140 generate the output streams on output channels 160 according to the outputs to be mapped to the respective inputs. The bitstreams 270 and 272 represent the multiplexed streams on output channels 160. After a block of  $N$  bits is written to the first portions



250, 254 of the RAMS 145, they switch roles with the second portions 252, 256 and are read while the second portions 250 and 256 are written to. The two portions 252, 256 and 250, 254 alternate between read and write continuously as  
5 data is fed through.

Although in the embodiment described above, a single bit from each input channel is read into RAMs 145 before the first and second portions 252, 256 and 250, 254 switch roles, it is obvious that this can be done on any  
10 desired schedule as desired. That is, more than one bit input per channel 1-N could be buffered in the RAMs 145. Also, where some channels are characterized by a higher data rate than others, the number of bits buffered in the RAMs 145 need not be the same for each channel 1-N.

15 It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrative embodiments, and that the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof.

20 The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes

which come within the meaning and range of equivalency of  
the claims are therefore intended to be embraced therein.